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Progress Report
NASA Planetary Atmospheres Program
NAG5-6998 "Reference Atmosphere for Mercury"

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We propose that ^{40}Ar measured in the lunar atmosphere and that in Mercury's atmosphere is due to current diffusion into connected pore space within the crust. Higher temperatures at Mercury, along with more rapid loss from the atmosphere will lead to a smaller column abundance of argon at Mercury than at the Moon, given the same crustal abundance of potassium. Because the noble gas abundance in the Hermean atmosphere represents current effusion, it is a direct measure of the crustal potassium abundance. ^{40}Ar in the atmospheres of the planets is a measure of potassium abundance in the interiors, since ^{40}Ar is a product of radiogenic decay of ^{40}K by electron capture with the subsequent emission of a 1.46 eV γ -ray. Although the ^{40}Ar in the Earth's atmosphere is expected to have accumulated since the late bombardment, ^{40}Ar in the atmospheres of Mercury and the Moon is eroded quickly by photoionization and electron impact ionization. Thus, the argon content in the exospheres of the Moon and Mercury is representative of current effusion rather than accumulation over the lifetime of the planet.

We consider the source and loss processes for the argon atmospheres of Mercury and the Moon in order to investigate what these atmospheres tell us about the structure and composition of the megaregolith. Argon is especially important because it does not engage in chemistry. In order to interpret measurements of argon in Mercury's atmosphere, we must have a model including sources from the interior and loss from the atmosphere. Our model was trained on the Moon, where in-situ measurements are available from instruments left on the surface by the Apollo 17 astronauts. First we consider production of ^{40}Ar from K, and its diffusion to the surface. We assume a fractal

distribution of effective unit sizes, and we assume that the minimum unit size increases with depth. Detailed calculations of diffusion of argon through a regolith and megaregolith have not been published previously. We do not consider diffusion in the atmosphere itself since this was adequately considered by Hodges in the 1970's; rather, we consider diffusion and effusion of radiogenic argon from its source in the megaregolith to the surface, and loss from the atmosphere.

We expect that the atmospheric argon abundance at Mercury to be less than or comparable to that at the Moon. This is in sharp contrast with the sodium and potassium atmospheres of the two bodies, where the Hermean abundance of sodium is two orders of magnitude greater than that at the Moon. This results from differences in the source processes of the alkalis and the rare gases. The former are preferentially derived from photon-stimulated desorption, which increases as the inverse square distance from the sun. The argon is derived by diffusion from within the crust. Although the diffusion coefficients depend exponentially on temperature, the rate is limited by the radiogenic production rate and by the distance between connected pore space. These parameters have been assumed to be fractal.

In future work, we will consider Capture of ^{20}Ne from the solar wind and its implications for capture of ^{36}Ar . We will also consider the sources of atmospheric calcium. Under a separate grant we are considering how the Hermean magnetosphere affects the loss of argon. Because argon is both heavy and accommodated to the surface temperature, its scale height will be much smaller than the distance to the magnetopause. It is important to model this effect on the argon loss rate in order to understand measurements of atmospheric argon.

Papers presented at scientific meetings:

Killen, R.M. and T.H. Morgan, 2001, Ar Atmosphere: Implications for Structure and Composition of Mercury's Crust. *Proceedings of the European Geophysical Society Meeting*, Nice, France.

Killen, R.M., 2001 Argon Atmospheres of Mercury and the Moon, Proceedings of Div. Planetary Science Conf., *Bull. Am. Astron. Soc.* **33** #3, 1027.

Killen, R.M. and T.H. Morgan, 2001, Ar Atmosphere: Implications for Structure and Composition of Mercury's Crust. *Mercury: Space Environment, Surface and Interior*, Field Museum, Chicago, Ill., Oct.4-5, 2001.

Papers resulting from this grant:

Killen, R.M., Source and Maintenance of the Argon Atmospheres of Mercury and the Moon, *Meteoritics and Planetary Science*, Submitted Jan., 2002.